

3.4 Cumulative distributions of model results

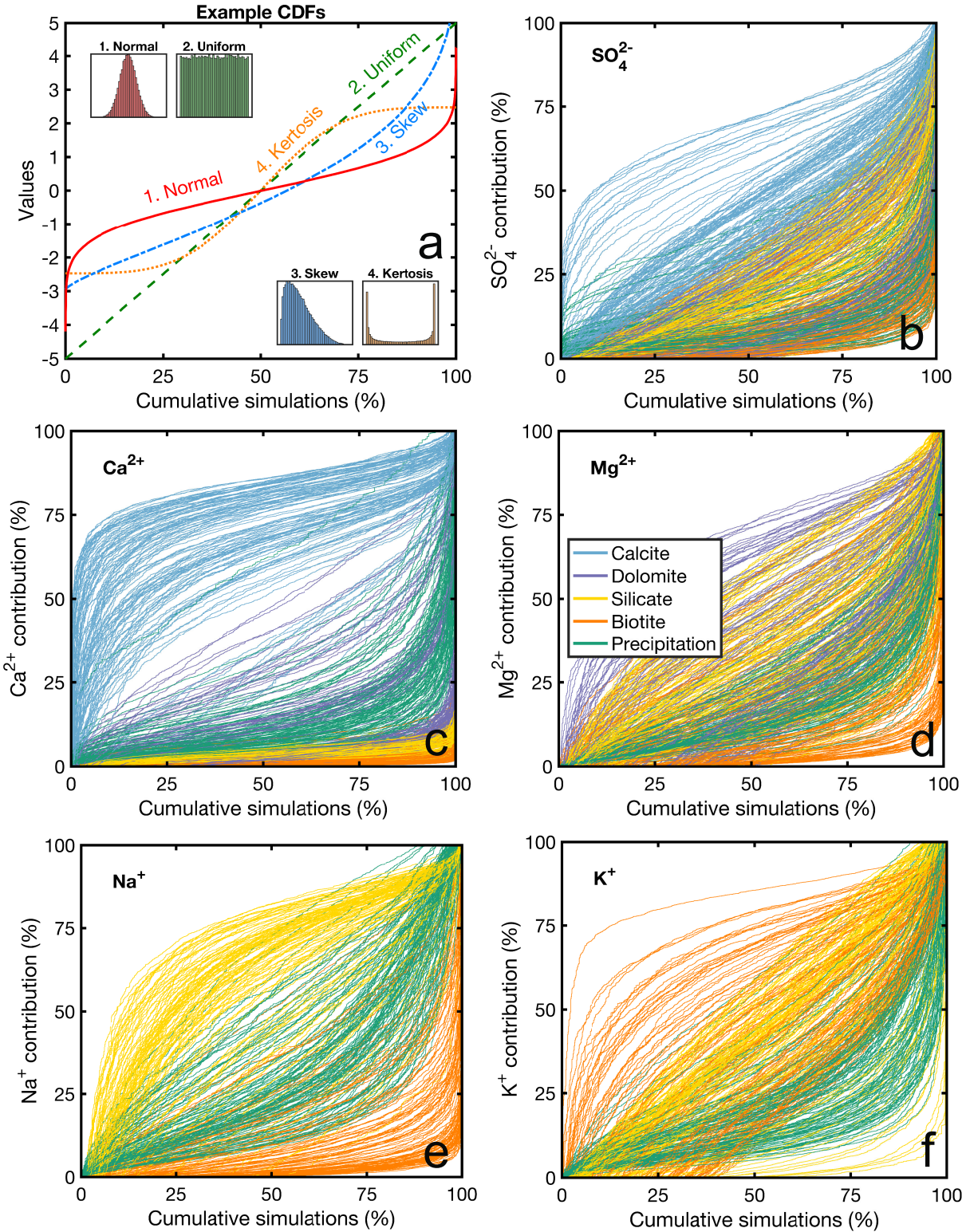


Fig. S10: (a) Example cumulative distribution functions for common distributions. Cumulative distribution functions for the fractional contributions of (b) SO_4^{2-} (c) Ca^{2+} , (d) Mg^{2+} , (e) Na^+ , and (f) K^+ for the primary inversion model described in the main text.

3.5 Month-specific and location-specific RZ regressions

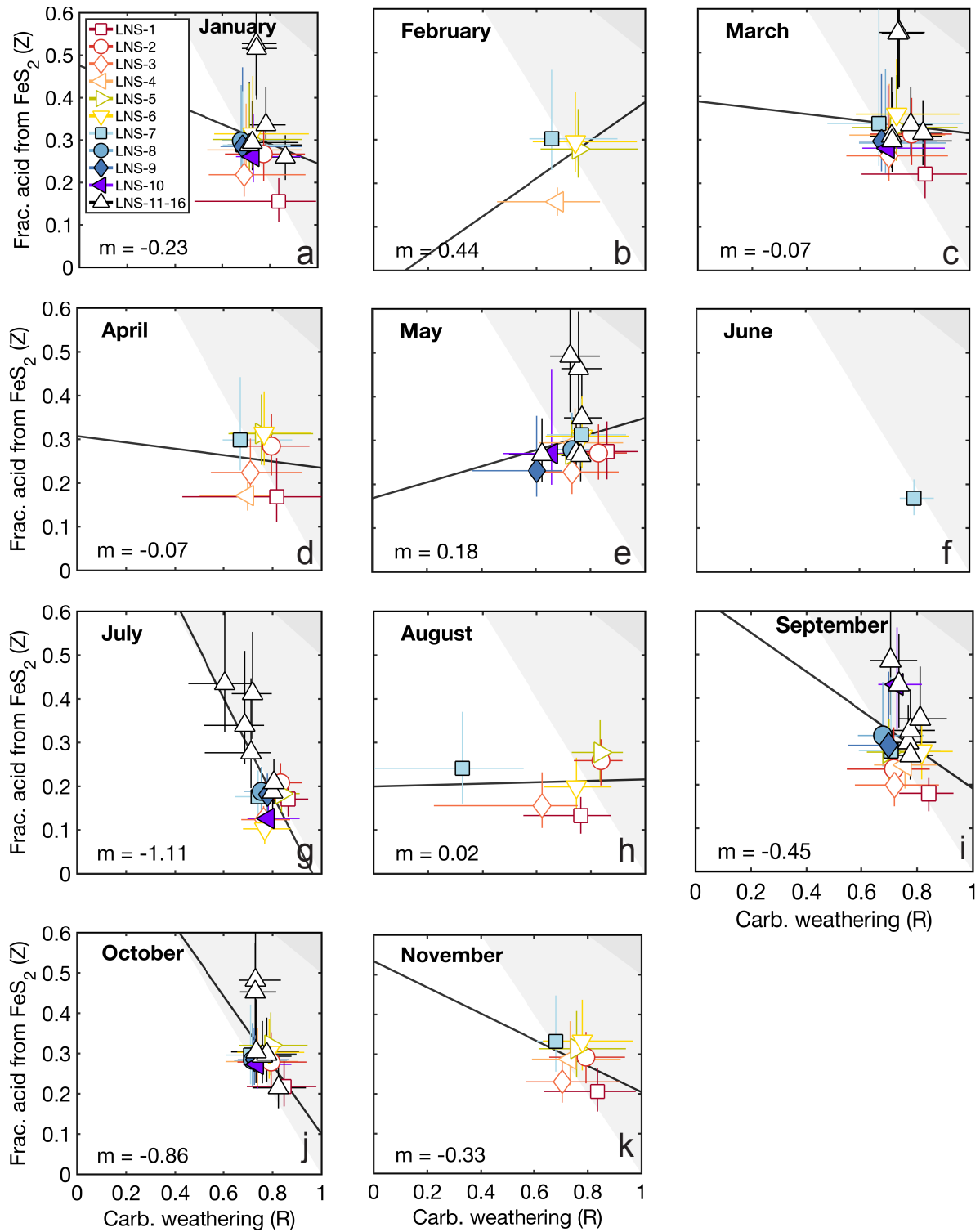


Fig. S11: Regressions by month of the fraction of weathering done by sulfuric acid (Z) against the fraction of carbonate weathering (R) yields both positive and negative slopes.

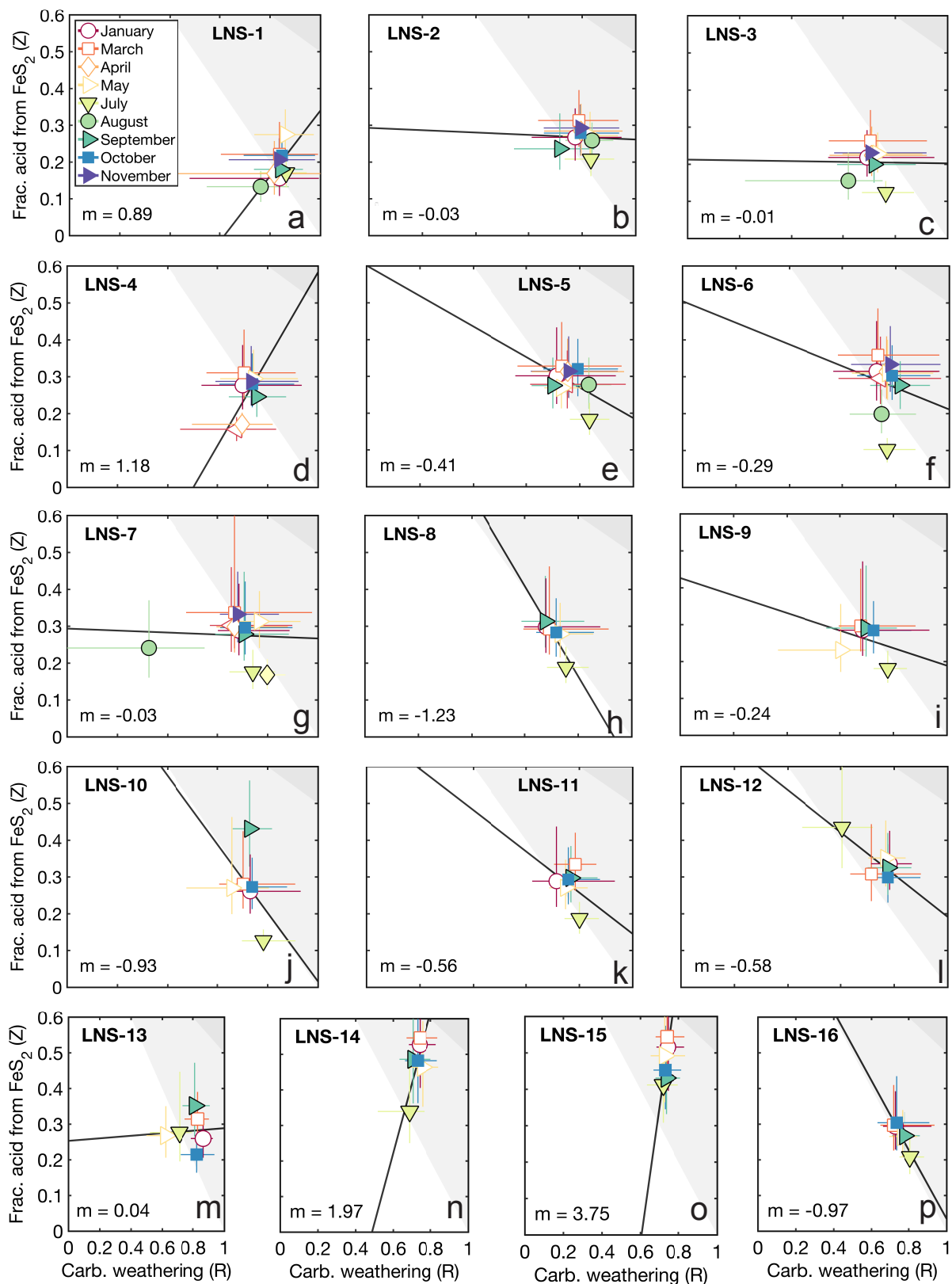


Fig. S12: Regressions by site of the fraction of weathering done by sulfuric acid (Z) against the fraction of carbonate weathering (R) yields both positive and negative slopes.

3.6 Inversion-constrained $\delta^{34}\text{S}_{\text{FeS}_2}$ against catchment lithology

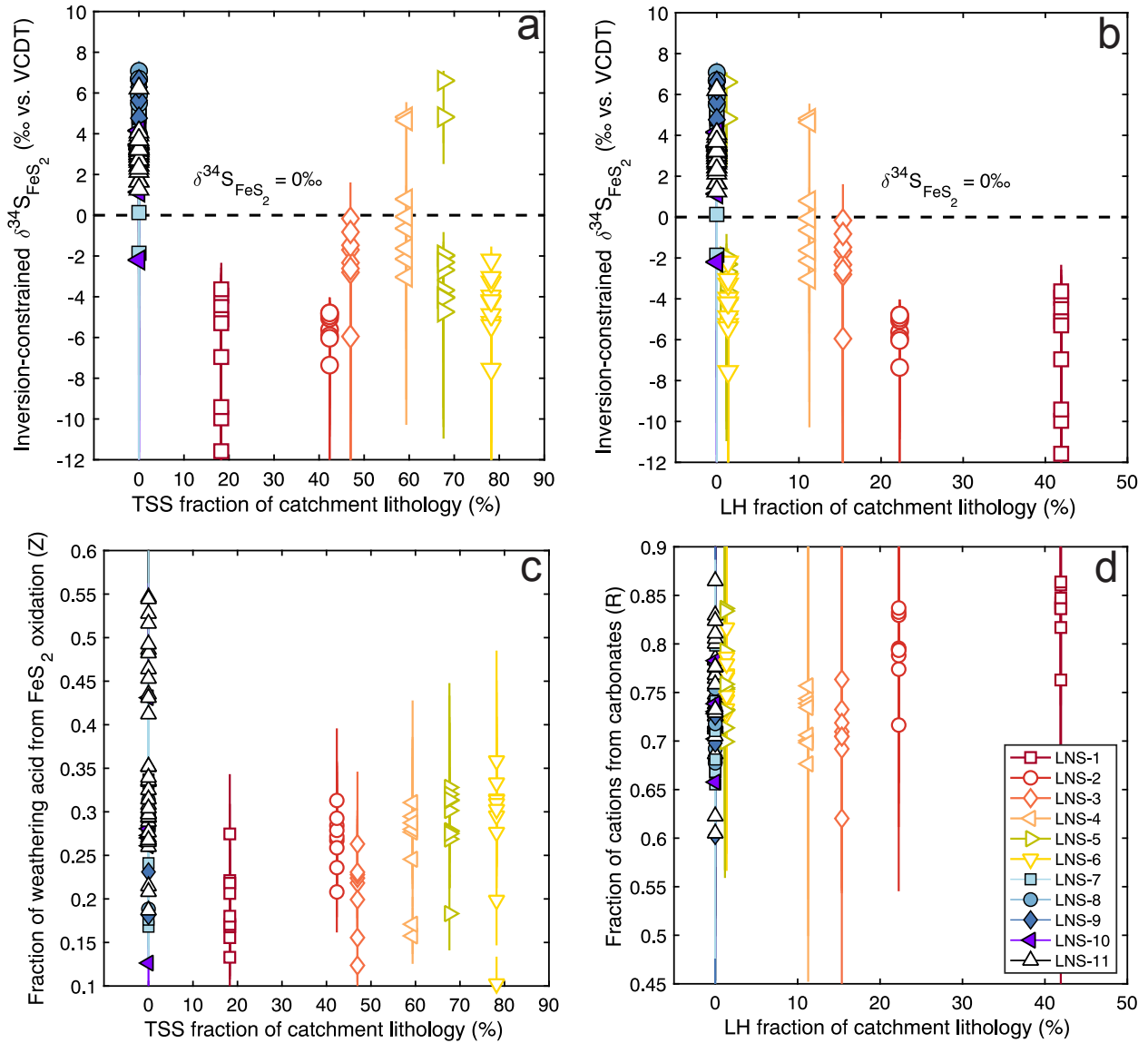


Fig. S13: Inversion-constrained $\delta^{34}\text{S}_{\text{FeS}_2}$ against the fractional exposure of the (a) Tethyn Sedimentary Series (TSS) and (b) Lesser Himalayan (LH) formations within each sample catchment. (c) Fraction of weathering acid sourced from FeS_2 oxidation (Z) against the fractional exposure of TSS in each catchment. (d) Fraction of cations sourced from carbonate weathering (R) against the fractional exposure of LH in each catchment. For all panels, error bars range from the 5th to 95th percentiles of accepted simulation results.

3.7 Seasonality of R and Z in prior datasets

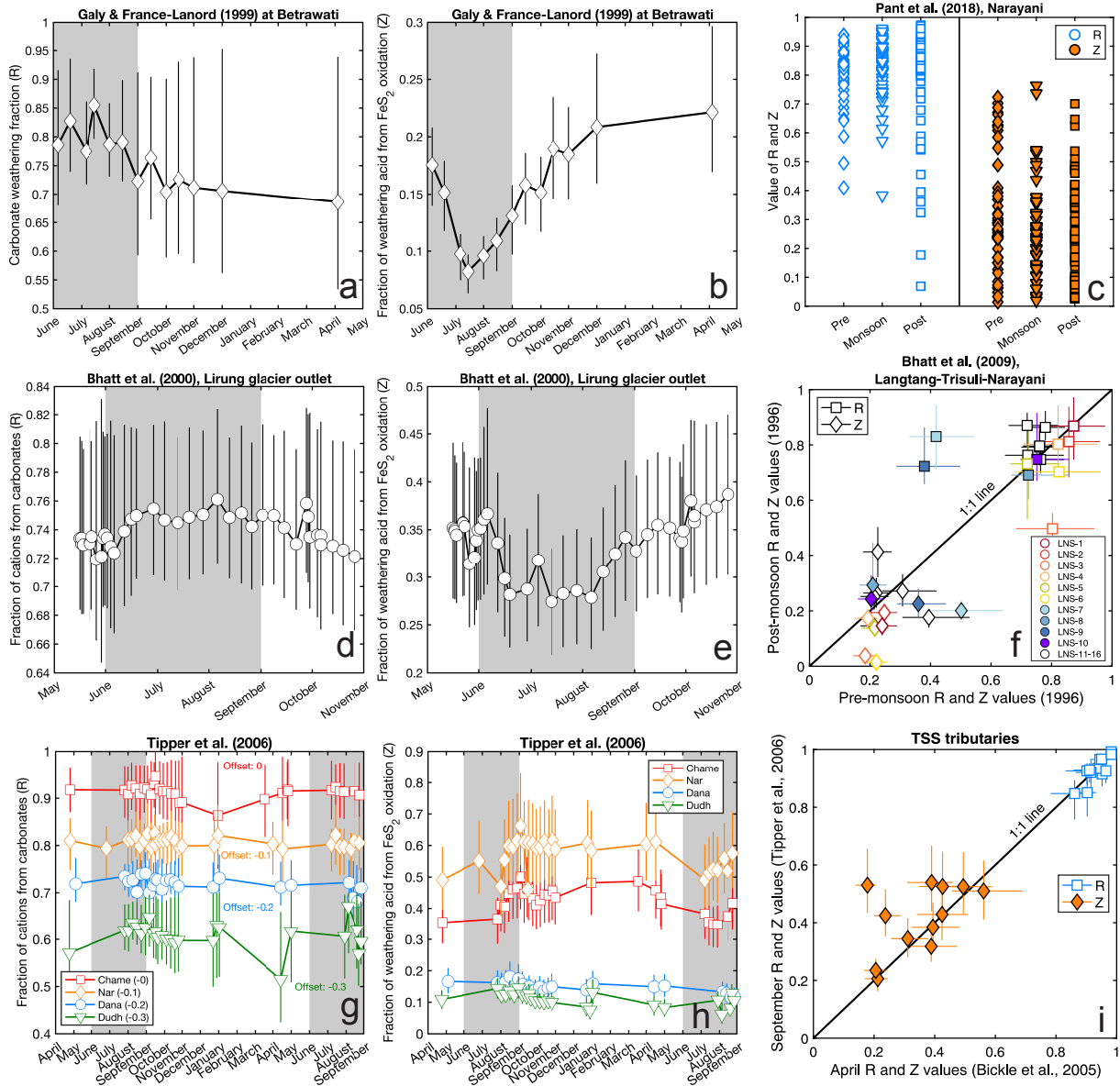


Fig. S14: Seasonality of R and Z in prior data from the Narayani River catchment. (a) R and (b) Z in the Trisuli River at Betrawati (Galy & France-Lanord, 1999). R is higher and Z lower during the monsoon than during the non-monsoon season. (c) R and Z are similar during the pre-monsoon, monsoon, and post-monsoon season in Narayani samples (Pant et al., 2018). (d) R and (e) Z in meltwater from the Lirung Glacier (Bhatt et al., 2000). Seasonal change in R is present, although muted relative to the Trisuli River, and is clear in Z. (f) R and Z of pre-monsoon and post-monsoon samples from the same 16 sites in this study (Fig. 1), collected in 1996 (Bhatt et al., 2009). Neither R nor Z is systematically higher in either season. (g) R and (h) Z values at four sites in the Marsyandi (Tipper et al., 2006). The Chame and Nar show lower monsoon values of Z, while seasonality in R is not recovered clearly. This result contrasts with that reached when considering Si(OH)₄/Ca²⁺ and ⁸⁷Sr/⁸⁶Sr ratios. (i) R and Z in Marsyandi samples collected in April/May (Bickle et al., 2005) and September (Tipper et al., 2006) from tributaries draining the TSS. Neither R nor Z is systematically enriched in either month. In all panels grey shading indicates monsoon season.